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Improving Corn and Tankage for Pigs Not on Pasture

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IMPROVING CORN AND TANKAGE FOR PIGS NOT ON PASTURE

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Tankage is produced and used in greater abundance than any other protein concentrate commonly fed to hogs. Only a few feeds surpass it in value as a single supplement to corn or other grains (32); yet pigs without pasture often fail to thrive as they should on corn and tankage alone. This is especially true of fall pigs that are farrowed rather late and do not get a good start on forage before they are placed in winter quarters. Experiments conducted during the past few years have shown methods whereby a corn and tankage ration may be improved for winter or dry-lot feeding.

With the few exceptions noted later, the pigs used in the investigations herein reported were confined throughout the tests in 10- by 12-foot pens of a central house, having a concrete floor equipped with wooden inlays for beds. In some of the trials the rations were fed twice daily or were hand-fed. In the others they were self-fed. Instead of each feed being placed in a separate compartment of the feeder and fed "free-choice", the feeds were mixed and fed in definite proportions, regardless of whether self- or hand-feeding was practiced. Since pigs, as they become older, need a smaller percentage of protein in the ration, the proportion of corn was increased and the supplement reduced, when a specified weight (from 100 to 125 pounds) was reached. Yellow corn was used in all of the experiments.

SCHEDULE OF PRICES USED

Shelled corn	$ .84	bu.	Skimmed milk	$ .35	cwt.
Oats	.44	bu.	Grinding corn or hulled oats	.10	cwt.
Hulled oats	47.40	ton	Grinding oats	.15	cwt.
Rice polish	36.00	ton	Salt	1.00	cwt.
Flour middlings	32.00	ton	Pulverized limestone	.50	cwt.
Standard middlings	28.00	ton	Special steamed bone meal	2.50	cwt.
Palmo Midds	28.00	ton	Raw bone meal	3.00	cwt.
Cocoanut oilmeal	34.00	ton	Spent bone black	1.50	cwt.
Cocoa bean oilmeal	32.00	ton	Glauber's salts	4.00	cwt.
Tankage, steam-rendered	70.00	ton	Copperas	4.00	cwt.
Dry-rendered tankage	80.85	ton	Iron oxide	5.00	cwt.
Linseed meal	45.00	ton	Potassium iodide	5.00	lb.
Cottonseed meal	40.00	ton	Cod-liver oil	.15	lb.
Alfalfa hay	24.00	ton	Yeast	.70	lb.
Ground alfalfa	32.00	ton			
Chopped clover or alfalfa	32.00	ton			

FEEDING MINERALS WITH CORN AND TANKAGE

Limestone.—Since limestone was previously found to be beneficial with rations of corn and protein concentrates of plant origin (35), feeding it with corn and tankage was tried. Table 1

summarizes four experiments in which from 1 to 1.5 per cent of limestone was added to rations of corn, tankage, and salt. The pigs given the limestone reached a market weight of 200 pounds 23 days earlier than those given the same ration without the limestone; they also required an average of 9.4 pounds less feed for each 100 pounds of gain. Apparently, a ration of corn and tankage is somewhat deficient in calcium for optimum results.

TABLE 1.—Effect of Feeding Limestone With Corn and Tankage

	1 Corn Tankage Salt	2 Corn Tankage Salt Limestone
Number of experiments	4	4
Number of pigs	33	32
Initial weight per pig, lb.	48.6	48.9
Final weight per pig, lb.	193.2	192.9
Average daily gain, lb.	**.87**	**1.01**
Days required to gain 150 lb	172	149
Daily feed per pig, lb.:		
Corn	3.32	3.69
Tankage	.34	.37
Salt or minerals	.01	.07
Total	**3.67**	**4.13**
Feed per 100 lb. gain, lb.:		
Corn	379.89	366.89
Tankage	39.54	37.44
Salt or minerals	1.02	6.70
Total	**420.45**	**411.03**
Cost of feed per 100 lb. gain	$ 7.47	$ 7.22

Lot 1: A 41-lb. pig was taken out after 98 days, in one experiment, and an 81-lb. one after 112 days in another.
Lot 2: A 48-lb. pig was taken out after 98 days, in one experiment.

Copperas.—Copperas, or iron sulphate, with a mineral mixture of salt, limestone, and spent bone black was tried in the experiment reported in Table 2. Twenty per cent of copperas was included in the mineral mixture and one pound of minerals was mixed with each 99 pounds of feed. Thus, the copperas made up one-fifth of one per cent of the total ration.

Glauber's salts.—Glauber's salts, or sodium sulphate, which is laxative in character, was likewise used with salt, limestone, and spent bone black. It was fed at the same rate as the copperas. Both the pigs getting Glauber's salts and those getting copperas gained more rapidly and required less feed per unit of gain than those on the check ration. A single trial, however, is not regarded as conclusive. The data are presented as contributions on the questions involved rather than as proof of a need for either Glauber's salts (16) or copperas (6).

TABLE 2.—Comparison of Minerals for Feeding With Corn and Tankage

Experiment started August 12, 1926	1	2	3
	Corn and tankage		
Mineral mixture	Salt 20 Limestone 40 Spent bone black 40	Salt 16 Limestone 32 Spent bone black 32 **Glauber's salts 20**	Salt 16 Limestone 32 Spent bone black 32 **Copperas 20**
Number of pigs	6	6	6
Initial weight per pig, lb.	77.1	76.2	76.7
Final weight per pig, lb.	205.6	206.9	210.8
Average daily gain, lb.	**1.41**	**1.44**	**1.60**
Days required to gain 135 lb.	96	94	85
Daily feed per pig, lb.:			
Corn	5.66	5.22	5.41
Tankage	.58	.54	.56
Minerals	.06	.06	.06
Total	**6.30**	**5.82**	**6.03**
Feed per 100 lb. gain, lb.:			
Corn	401.02	363.76	338.76
Tankage	40.95	37.29	35.04
Minerals	4.46	4.05	3.78
Total	**446.43**	**405.10**	**377.58**
Cost of feed per 100 lb. gain	$ 7.89	$ 7.19	$ 6.71

Bone meal.—A combination of limestone and a bone product, or a phosphorus-containing material, was superior to either alone for feeding with corn, soybean oilmeal, and salt (35). Tankage, containing 60 per cent of protein, analyzes approximately 15.3 per cent ash or minerals, which, of course, is largely bone. Thus, whether additional bone material is needed, when appreciable quantities of tankage are fed, would seem to be a legitimate question. Table 3 reports an experiment in which mixtures of salt and limestone; of salt, limestone, and bone meal; and of salt, limestone, and iron oxide were fed with a ration of corn, tankage, and linseed meal. During the experiment the pigs were kept in outside, paved lots and sheltered in movable houses. Regardless of the mixture used, 1.5 pounds of minerals were mixed with each 98.5 pounds of feed. Self-feeding was practiced.

Substituting bone meal for half of the limestone in the mineral mixture resulted in no faster growth and saved only 4.9 pounds of feed for each 100 pounds of gain produced. This difference, especially since only a few animals were used in the experiment, is probably too small to be significant.

Iron oxide.—The iron oxide used was a finely pulverized material containing approximately 14 per cent of impurities. The pigs receiving it gained 10 per cent more rapidly and required 9.3

per cent less feed per unit of gain than those getting a similar ration to which no iron oxide was added. Although the data are insufficient to be conclusive, the results of this trial, as well as of those reported in Table 2, indicate that additional iron may be beneficial with a corn and tankage ration.

TABLE 3.—Comparison of Minerals for Feeding With Corn, Tankage, and Linseed Meal

	1	2	3
	Corn, tankage, and linseed meal		
	Salt 20 Limestone 80	Salt 20 Limestone 40 **Bonemeal 40**	Salt 19.4 Limestone 77.6 **Iron oxide 3.0**
Number of pigs	7	7	7
Initial weight per pig, lb.	47.9	48.8	48.0
Final weight per pig, lb.	208.0	216.3	223.1
Average daily gain, lb.	**1.20**	**1.19**	**1.32**
Days required to gain 160 lb.	134	135	121
Daily feed per pig, lb.:			
Corn	3.93	3.84	3.90
Supplement*	.51	.49	.50
Minerals	.07	.07	.07
Total	**4.51**	**4.40**	**4.47**
Feed per 100 lb. gain, lb.:			
Corn	326.81	322.89	296.48
Supplement*	42.31	41.37	38.32
Minerals	5.62	5.55	5.10
Total	**374.74**	**369.81**	**339.90**
Cost of feed per 100 lb. gain	$ 6.57	$ 6.53	$ 5.96

*Supplement=Tankage, 2; linseed meal, 1.
Lot 3: A 68.5-lb. pig was taken out after 28 days and a 64-lb. one after 70 days.

YEAST FOR PIGS

Yeast is rich in vitamins B and G, or in the antineuritic and antipellagric vitamins, and, probably, also in one or more other factors. It has been advertised as a desirable constituent of rations for pigs. Table 4 gives the results of a test made to determine the effect of yeast in the ration.

A mixture of ground yellow corn, tankage, and minerals was fed to three groups of pigs. The feed for one group was prepared by adding water and allowing it to soak for 24 hours. That for the second group was prepared in the same way except that it was fermented with commercial yeast, added at the rate of approximately a fifth of a per cent of the dry feed. The feed for the third group was fermented with self-propagated yeast, prepared at the outset from a little commercial yeast as a starter. Thereafter, instead of using commercial yeast a little of the liquor, containing growing

yeast, from the feed which had been prepared the previous day was poured into the newly made slop. This slop was then allowed to ferment for 24 hours in a heated room, just as was that for the lot getting the feed to which fresh commercial yeast was added each time. Since growing yeast gives off carbon dioxide, fermentation in the slop could be determined by the presence of bubbles rising to the surface of the mixture.

It was necessary to renew the culture for the third group only a few times during the course of the experiment; hence, only a very small amount of purchased yeast, 25 cents' worth, was required. Approximately 8.5 pounds of commercial yeast were fed to the second group; at 70 cents a pound its cost was $5.95.

TABLE 4.—Yeast-fermented Feed for Pigs

	1	2	3
	Corn, tankage, and minerals		
	Unfermented	Fermented with commercial yeast*	Fermented with self-propagated yeast
Number of pigs	7	7	7
Initial weight per pig, lb.	57.4	57.6	57.7
Final weight per pig, lb.	238.1	236.8	240.6
Average daily gain, lb.	**1.08**	**1.10**	**1.09**
Days required to gain 180 lb.	167	164	165
Daily feed per pig, lb.:			
Corn	3.81	3.86	3.82
Tankage	.37	.38	.38
Minerals	.08	.09	.09
Total	**4.26**	**4.33**	**4.29**
Feed per 100 lb. gain, lb.:			
Corn	353.93	349.82	351.53
Tankage	34.12	34.72	35.36
Minerals	7.92	7.85	7.89
Total	**395.97**	**392.39**	**394.78**
Cost of feed per 100 lb. gain	$ 6.91	$ 7.40	$ 6.93

*Approximately 8.5 lb. of yeast were fed.
Lot 2: An 86-lb. pig was taken out after 119 days.
Lot 3: A 72-lb. pig was taken out after 98 days.

The differences in the rapidity of the gains and the amounts of feed required per unit of gain were too small to be of any significance. In six tests at other stations (3, 4, 22, 27, 40), pigs receiving yeast-fermented feeds and others receiving the same rations prepared in the same way, except that no yeast was added, made average gains of 1.20 and 1.19 pounds daily a head and required 417.2 and 422.9 pounds of feed, respectively, for each 100 pounds of gain produced.

Including a half per cent of yeast in the ration without fermenting the feed was tried by Morrison and Fargo (27) and by Brown and Edwards (3), but the yeast failed to increase either the rate of growth or the gain from a given quantity of feed.

The germs of seeds and green plant tissue, or the tips of immature growing plants, are both especially rich in vitamin B. Hence, whole grains, their germ-containing by-products, green pasture crops, and leafy hays all contain fairly liberal quantities of the antineuritic factor. The antipellagric factor is found in abundance in milk and animal by-products, green feeds, and leafy hays. Fermenting some rations with yeast might conceivably increase their palatability. Yeast could possibly prove beneficial in other rations, because of its laxative effect or because of some other constituent carried. Rations, too, could be selected which would be deficient in vitamin B or G, but, since each is contained in one or more of the feeds commonly fed to pigs, it is not surprising to find that yeast usually resulted in no marked improvement in the ration. However, if yeast should be needed, it could be self-propagated and supplied at a negligible cost.

COD-LIVER OIL

Cod-liver oil is especially rich in vitamins A and D, or in anti-xerophthalmic and antirachitic vitamins. If a combination of yellow corn and tankage is deficient in either of these vitamins, the use of a small amount of cod-liver oil should improve the ration. Table 5 summarizes three experiments in which the inclusion of half a per cent of cod-liver oil in a ration of corn, tankage, and minerals was tried. Adding cod-liver oil to the ration increased the gain in liveweight per unit of feed in two of the experiments and the rapidity of the gains in one of the three experiments. The summary shows the addition of cod-liver oil to have produced greater gains from a given amount of feed but no faster gains. In a test at the Iowa Station (12) pigs getting cod-liver oil with a ration of corn, tankage, and minerals not only made more gain per unit of feed but also made more rapid growth than similar pigs without it.

Yellow corn is fairly rich in vitamin A but white corn contains no appreciable amount. Trials at the Wisconsin Station (28) showed yellow corn to be superior to white corn for pigs in dry lot, getting no leguminous hay. When the pigs were on pasture or were given a ration containing 5 per cent of chopped alfalfa, white corn produced as rapid and as economical gains as yellow corn.

Results of tests at the Nebraska (23) and Illinois (30) Stations, comparing white and yellow corn for pigs in dry lot, were in accord with those of the Wisconsin Station. Animals are apparently capable of storing sufficient quantities of vitamin A in their bodies to meet their needs for some time. Consequently, the effects of a deficiency do not ordinarily show up until after the animals have received a vitamin-A deficient ration for several weeks.

TABLE 5.—Comparison of Cod-liver Oil and a Mixture of Linseed Meal and Ground Alfalfa for Feeding With Corn and Tankage

	1 Corn Tankage Minerals	2 Corn Tankage Cod-liver oil Minerals	3 Corn Tankage Linseed meal Ground alfalfa Minerals
Number of experiments	3	3	3
Number of pigs	22	21	23
Initial weight per pig, lb.	49.4	50.0	48.7
Final weight per pig, lb.	196.0	195.4	195.5
Average daily gain, lb.	**1.03**	**1.03**	**1.14**
Days required to gain 150 lb.	146	146	132
Daily feed per pig, lb.:			
Corn	3.68	3.58	3.80
Tankage	.34	.32	.31
Linseed meal	.06*	.06	.14
Ground alfalfa	.....	.....	.15
Minerals	.07	.07	.04
Cod-liver oil	.....	.02	.....
Total	**4.15**	**4.05**	**4.44**
Feed per 100 lb. gain, lb.:			
Corn	358.30	346.80	332.17
Tankage	33.11	31.24	27.41
Linseed meal	5.78*	5.70	12.82
Ground alfalfa	.....	.....	13.16
Minerals	6.63	6.35	3.27
Cod-liver oil	.....	1.96	.....
Total	**403.82**	**392.05**	**388.83**
Cost of feed per 100 lb. gain	$ 7.07	$ 7.11	$ 6.80

*Linseed meal was included in the rations for Lots 1 and 2 in one experiment.
Lot 1: A 48-lb. pig was taken out after 98 days in one experiment.
Lot 2: A 39-lb. pig was taken out after 98 days in one experiment.

Green feeds or pasture crops contain relatively large amounts of vitamin A. Leafy hays also carry a fairly liberal quantity but may differ greatly in their vitamin-A content. Russell, of the New Jersey Station (39), found that alfalfa leaves dried by artificial heat had a vitamin-A content about seven times greater than that of leaves of plants cured in the field.

The addition of a mixture of ground alfalfa and linseed meal, as well as the addition of cod-liver oil, to the corn, tankage, and mineral ration was tried in the Ohio experiments. The ground alfalfa made up an average of 3.4 per cent of the total feed. The feed consumption per unit of gain, for the pigs getting cod-liver oil and for those getting the ground alfalfa and linseed meal, was practically the same.

TABLE 6.—Effect of Untreated and Aerated Cod-liver Oil, Ground Alfalfa, and Sunlight on Pigs Fed Corn, Tankage, Linseed Meal, and Minerals

	1 Corn Tankage Linseed meal Minerals	2 Corn Tankage Linseed meal Minerals **Sunlight***	3 Corn Tankage Linseed meal **Aerated cod-liver oil** Minerals	4 Corn Tankage Linseed meal **Cod-liver oil** Minerals	5 Corn Tankage Linseed meal **Ground alfalfa** Minerals
Number of experiments	2	2	2	2	2
Number of pigs	16	15	16	14	16
Initial weight per pig, lb.	44.5	44.3	43.8	45.4	44.3
Final weight per pig, lb.	199.0	200.5	199.4	201.3	201.7
Average daily gain, lb.	**1.11**	**1.12**	**.99**	**1.04**	**1.18**
Days required to gain 155 lb.	140	139	157	149	132
Daily feed per pig, lb.:					
Corn	3.80	3.76	3.29	3.43	3.75
Tankage	.32	.32	.30	.32	.31
Linseed meal	.16	.16	.07	.08	.16
Ground alfalfa	.....	.....	.....	.....	.16
Minerals	.08	.08	.07	.07	.05
Cod-liver oil	.....	.....	.02	.02	.....
Total	**4.36**	**4.32**	**3.75**	**3.92**	**4.43**
Feed per 100 lb. gain, lb.:					
Corn	343.04	337.37	332.67	330.91	316.55
Tankage	29.16	28.73	30.86	30.57	26.47
Linseed meal	14.58	14.37	7.03	8.17	13.24
Ground alfalfa	.....	.....	.....	.....	13.24
Minerals	6.84	6.77	6.63	6.46	4.74
Cod-liver oil	.....	.....	1.90	1.89	.....
Total	**393.62**	**387.24**	**379.09**	**378.00**	**374.24**
Cost of feed per 100 lb. gain	$ 6.89	$ 6.78	$ 6.90	$ 6.88	$ 6.53

*The pigs were fed the same as Lot 1 but were given access to an outside pen having a board floor.

Linseed meal was included in the rations containing cod-liver oil, in only one experiment.

Lot 1: A 27-lb. pig was taken out after 91 days in one experiment.
Lot 2: A 50.5-lb. pig was taken out after 56 days in one experiment.
Lot 3: A 47.5-lb. pig was taken out after 56 days in one experiment and a 47-lb. one after 98 days in another.
Lot 4: A 39-lb. pig was taken out after 98 days in one experiment.

By aerating, or oxygenating, cod-liver oil its vitamin-A content can be destroyed and its vitamin-D content left intact. Both aerated and untreated cod-liver oil were fed in two experiments. The pigs given the aerated cod-liver oil made as much gain from a given amount of feed but failed to gain quite as rapidly as those getting the untreated cod-liver oil. As compared with the feed required by the check group, averages of 14.5 and 15.5 pounds of feed for each 100 pounds of gain were saved by the aerated and by the untreated cod-liver oil, respectively.

IMPORTANCE OF SUNLIGHT

Ultra-violet light, like vitamin D, aids in the assimilation of calcium and phosphorus, or in bone formation. The ultra-violet

rays are too short to be visible to the human eye. They are the rays which cause tanning and they pass through quartz glass but not through ordinary window glass.

As previously mentioned, most of the pigs used in these tests were confined indoors throughout the experiments. To determine whether exposure to sunlight would prove beneficial to pigs receiving yellow corn, tankage, linseed meal, and minerals, two groups of pigs in each of the experiments summarized in Table 6 were fed this ration. One group was kept indoors in a 10- by 12-foot pen, floored with concrete except for the bed, which was of wood. The other was kept in a similar indoor pen but also had access to an outside pen of equal size, which had a board floor. In the first experiment the pigs having access to the outside pen made both faster gains and greater gains from a given amount of feed than those kept inside. This difference occurred chiefly in the spring when there was more sunshine than there had been earlier, or during the winter. In the second experiment nothing was gained by allowing the pigs access to an outside pen.

Evvard and his co-workers (12) tried irradiating pigs with ultra-violet light from a mercury vapor lamp. The ration used was yellow corn, tankage, and minerals. The irradiated pigs required 30 pounds less feed per 100 pounds of gain produced than the untreated pigs and 5 pounds less than untreated pigs receiving the same ration plus cod-liver oil.

These findings indicate that allowing the pigs to run out in the sunshine will reduce the need for a vitamin-D-rich material in the ration. Often, however, there are not many sunshiny days during the winter months; hence, as a precautionary measure, even if the pigs are allowed to run outside, it would probably be advisable to use a small amount of some substance that is rich in vitamin D with a corn and tankage ration for winter feeding. A little ground alfalfa of good quality apparently furnishes a sufficient amount.

As previously mentioned, Russell (39) found that alfalfa leaves from plants dried artificially contained at least seven times as much vitamin A as leaves from hay cured in the field. He also found that the leaves of the artificially-cured plants contained only a small amount of vitamin D and that curing alfalfa in the sun without allowing it to be exposed to dew or rain increased the antirachitic potency of the leaves but reduced their vitamin-A content.

Cod-liver oil is an effective source of vitamin D but, because of its medicinal value, is relatively high priced. Smaller amounts than were used in the experiments reported would furnish as much of the antirachitic vitamin as was supplied in the amounts of ground

alfalfa fed. Nelson and Manning (29) have shown commercial tuna and pilchard, or sardine, oils to be as high in vitamin D as cod-liver oil. Although not as potent, menhaden oil was also shown to be a possible source of vitamin D. Tolle and Nelson (41) further report that oil has been prepared from salmon offal which is equally as potent in vitamin A and about twice as potent in vitamin D as good grades of medicinal cod-liver oil.

Although both vary considerably in their vitamin-D content, a fifth of a per cent of fish oil would be expected to supply fully as much vitamin D as would 5 per cent of ground alfalfa. At current prices salmon oil, or the other fish oils mentioned, are more economical sources of vitamin D than either cod-liver oil or commercial alfalfa meal.

FEEDING GROUND ALFALFA WITH CORN AND TANKAGE

Table 7 summarizes three trials in which ground alfalfa alone and linseed meal and ground alfalfa combined were added to a corn and tankage ration. Although it resulted in faster gains and in greater gains from a given amount of feed, the addition of ground alfalfa alone was not as effective in improving the ration as was the combination of linseed meal and ground alfalfa.

TABLE 7.—Comparison of Ground Alfalfa and of a Mixture of Ground Alfalfa and Linseed Meal for Feeding With Corn and Tankage

	1 Corn Tankage	2 Corn Tankage Ground alfalfa	3 Corn Tankage Linseed meal Ground alfalfa
Number of experiments	3	3	3
Number of pigs	21	21	21
Initial weight per pig, lb.	53.1	53.1	53.2
Final weight per pig, lb.	186.7	184.6	186.6
Average daily gain, lb.	**.96**	**1.01**	**1.08**
Days required to gain 150 lb.	157	149	139
Daily feed per pig, lb.:			
Corn	3.70	3.72	3.87
Tankage	.38	.37	.33
Linseed meal	.....	.....	.14
Ground alfalfa	.....	.13	.14
Minerals	.02	.02	.03
Total	**4.10**	**4.24**	**4.51**
Feed per 100 lb. gain, lb.:			
Corn	384.86	367.62	359.10
Tankage	39.49	36.58	30.40
Linseed meal	.....	.....	13.23
Ground alfalfa	.....	12.57	12.53
Minerals	2.63	2.23	2.48
Total	**426.98**	**419.00**	**417.74**
Cost of feed per 100 lb. gain	$ 7.56	$ 7.38	$ 7.33

A mineral mixture was fed in only one of the three experiments.

Lot 2: A 76-lb. pig was taken out after 70 days and a 108.5-lb. one after 84 days in one experiment.

FEEDING LINSEED MEAL WITH CORN AND TANKAGE

Omitting ground alfalfa and adding linseed meal alone was likewise tried in three experiments. These are reported in Table 8.

While a supplement of tankage and linseed meal produced faster gains than one of tankage alone, it did not materially lower the feed consumption per unit of gain. The trio supplemental mixture of tankage, linseed meal, and ground alfalfa, on the other hand, increased the rate of gain 26 per cent and lowered the feed requirement per unit of gain 9.8 per cent.

TABLE 8.—Comparison of Linseed Meal and of a Mixture of Linseed Meal and Ground Alfalfa for Feeding With Corn and Tankage

	1 Corn Tankage	2 Corn Tankage Linseed meal	3 Corn Tankage Linseed meal Ground alfalfa
Number of experiments	3	3	3
Number of pigs	22	23	23
Initial weight per pig, lb.	49.0	48.4	48.3
Final weight per pig, lb.	201.1	202.1	202.2
Average daily gain, lb.	**.97**	**1.11**	**1.22**
Days required to gain 150 lb.	155	135	123
Daily feed per pig, lb.:			
Corn	3.55	3.96	3.83
Tankage	.37	.34	.32
Linseed meal	.....	.17	.16
Ground alfalfa	.....	.....	.16
Minerals	.06	.07	.06
Total	**3.98**	**4.54**	**4.53**
Feed per 100 lb. gain, lb.:			
Corn	367.60	357.54	314.58
Tankage	37.87	30.71	26.11
Linseed meal	.....	15.36	13.06
Ground alfalfa	.....	.....	13.06
Minerals	6.76	6.83	5.05
Total	**412.23**	**410.44**	**371.86**
Cost of feed per 100 lb. gain	$ 7.26	$ 7.19	$ 6.49

Lot 1: A 33.5-lb. pig was taken out after 98 days in one experiment and a 36-lb. pig after 24 days in another.

Lot 2: A 141.5-lb. pig was taken out after 56 days, a 105-lb. one after 70 days in one experiment, and a 27-lb. pig after 91 days in another experiment.

FEEDING BOTH LINSEED MEAL AND GROUND ALFALFA WITH CORN AND TANKAGE

Table 9 gives the average results of nine experiments comparing tankage with tankage, linseed meal, and ground alfalfa for supplementing corn. Except that the differences are less marked, the findings agree with those of the three experiments reported in Table 8. The data for them are included in the general summary. In the nine trials the linseed meal and ground alfalfa increased the rate of growth 21.3 per cent and lowered the feed consumption per unit of gain 5 per cent.

TABLE 9.—Tankage Versus the Trio Mixture for Supplementing Corn

	1 Corn Tankage	2 Corn Tankage Linseed meal Ground alfalfa
Number of experiments	9	9
Number of pigs	69	70
Initial weight per pig, lb.	49.8	49.6
Final weight per pig, lb.	192.2	192.3
Average daily gain, lb.	.94	1.14
Days required to gain 150 lb.	160	132
Daily feed per pig, lb.:		
Corn	3.59	3.91
Tankage	.37	.33
Linseed meal	.....	.16
Ground alfalfa	.....	.15
Minerals or salt	.05	.05
Total	4.01	4.60
Feed per 100 lb. gain, lb.:		
Corn	380.54	342.56
Tankage	39.32	28.94
Linseed meal	.....	13.92
Ground alfalfa	.....	13.53
Minerals or salts	4.81	4.50
Total	424.67	403.45
Cost of feed per 100 lb. gain	$ 7.50	$ 7.06

Lot 1: A 36-lb. pig died on the 24th day in one experiment; a 41-lb. pig was taken out after 98 days in another, a 48-lb. one after 98 days in another, and a 104-lb. one after 84 days in another.

Lot 2: A 66-lb. pig was taken out after 68 days in one experiment, an 89-lb. one after 70 days in another, and a 111-lb. one after 70 days in another.

The Wisconsin Station (28) was probably the first to find that the mixture of tankage, linseed meal, and alfalfa was superior to tankage alone for supplementing corn for pigs in dry lot. The mixture was later tried at a number of other stations with similar results and in experimental work is now often used as the standard with which other supplements are compared. It is commonly referred to as the trio supplemental mixture. Although the percentages of the three feeds are sometimes varied, they are ordinarily mixed in the ratio of tankage 2, linseed meal 1, ground alfalfa 1.

WHOLE ALFALFA COMPARED WITH GROUND ALFALFA

Substituting whole hay for ground alfalfa was tried in only one experiment. Bright green, leafy hay of excellent quality was used. The hay for one group was kept before the pigs in a rack; whereas that for a second group was ground and mixed with the other feed. Table 10 summarizes the results secured.

TABLE 10.—Substituting Alfalfa Hay and Exposure to Sunlight for Ground Alfalfa

	1 Corn Tankage Linseed meal Minerals	2 Corn Tankage Linseed meal **Ground alfalfa** Minerals	3 Corn Tankage Linseed meal **Alfalfa hay*** Minerals	4 Corn Tankage Linseed meal **Sunlight†** Minerals
Number of pigs	8	8	8	7
Initial weight per pig, lb.	40.9	40.5	40.9	40.5
Final weight per pig, lb.	220.0	226.4	225.2	225.6
Average daily gain, lb.	**1.02**	**1.21**	**1.32**	**1.20**
Days required to gain 185 lb.	182	153	140	154
Daily feed per pig, lb.:				
Corn	3.61	3.90	4.25	4.05
Tankage	.30	.33	.34	.33
Linseed meal	.15	.17	.17	.16
Alfalfa	.....	.17	.36	.....
Minerals	.08	.09	.10	.09
Total	**4.14**	**4.66**	**5.22**	**4.63**
Feed per 100 lb. gain, lb.:				
Corn	354.63	323.47	322.31	336.87
Tankage	29.08	27.28	26.04	27.12
Linseed meal	14.54	13.64	13.02	13.56
Alfalfa	.....	13.64	27.42	.....
Minerals	8.13	7.71	7.38	7.71
Total	**406.37**	**385.74**	**396.17**	**385.26**
Cost of feed per 100 lb. gain	$ 7.07	$ 6.70	$ 6.74	$ 6.69

*The alfalfa hay was fed in a rack.

†The pigs were fed the same as Lot 1 but were given access to an outside pen having a board floor.

A 27-lb. pig was taken out of Lot 1 after 91 days. The pigs remaining in the lot at the close of the experiment made an average daily gain of 1.11 lb.

The pigs having access to the whole hay made faster gains than those given the ration containing the ground alfalfa. Some of the hay was wasted rather than eaten, but all that was placed in the rack was charged against the pigs. Aside from the alfalfa, the feed required per unit of gain was practically the same for the two lots.

Dry alfalfa is sometimes not especially palatable to pigs, and fattening pigs, or those on a full grain allowance, may not eat much hay if it is merely kept before them in a rack. This is true particularly if the quality of the alfalfa available is not of the best. On the other hand, if the alfalfa is ground it can be mixed with the other feeds, and the pigs can thus be forced to take a definite amount. If the pigs will eat the hay readily, apparently nothing is gained by grinding it. Five experiments at the South Dakota Station (21) showed that, as a rule, it paid to chop or grind the alfalfa and mix it with the other feeds rather than feed it as hay in a rack to growing and fattening pigs.

In the absence of ground alfalfa, a possible expedient would be to use the leaves which shatter off when hay is thrown from the mow for mixing with the feed for pigs during the winter months.

These are usually the drier, riper ones, and, while they would be expected to have considerable value, the greener ones at the tips of the branches would probably be richer in proteins and vitamins.

The check group of pigs in the experiment received no alfalfa. A fourth group was fed the same as the check group but was allowed the run of a 10- by 12-foot outside pen, having a board floor. This portion of the experiment is included in the summary of the two trials, showing the effect of exposure to sunlight, presented in Table 6. Allowing the pigs access to sunlight was apparently about as effective as alfalfa in increasing the rate of growth and the amount of gain from a given quantity of feed. As a precautionary measure, however, it is considered advisable to feed a little alfalfa or some substitute for it during the winter months, especially to young pigs, or to those under 100 pounds in weight.

CLOVER AS A SUBSTITUTE FOR ALFALFA

Red clover is grown on many farms on which no alfalfa is produced. To determine whether leafy clover could be substituted for alfalfa, chopped, second-growth clover of good quality was compared with chopped alfalfa of a similar grade for feeding with corn, tankage, linseed meal, and minerals. The pigs were started at the

TABLE 11.—Comparison of Red Clover and Alfalfa for Use in the Trio Mixture

Experiment started Dec. 11, 1924 Pigs confined indoors	1 Corn Tankage Linseed meal **Chopped alfalfa** Minerals	2 Corn Tankage Linseed meal **Chopped clover** Minerals
Number of pigs	11	11
Initial weight per pig, lb	26.4	26.4
Final weight per pig, lb	109.3	107.3
Average daily gain, lb	**.68**	**.70**
Daily feed per pig, lb.:		
Corn	2.47	2.56
Tankage	.24	.25
Linseed meal	.12	.12
Alfalfa or clover	.12	.12
Minerals	.05	.05
Total	**3.00**	**3.10**
Feed per 100 lb. gain, lb.:		
Corn	363.49	366.75
Tankage	35.25	35.56
Linseed meal	17.62	17.78
Alfalfa or clover	17.62	17.78
Minerals	6.61	6.67
Total	**440.59**	**444.54**
Cost of feed per 100 lb. gain	$ 7.83	$ 7.90

Lot 1: A 26-lb. pig was taken out after 98 days.
Lot 2: A 52-lb. pig, with the piles, was taken out on the 72nd day.

light average weight of 26 pounds. Since they were to be used as shotes in another experiment, the comparison was discontinued when an average weight of approximately 110 pounds was reached. The response of the two groups to the rations fed was practically the same. Although not conclusive, the findings indicate red clover to be as effective as alfalfa, if it is of equal quality. High quality, green, leafy, red clover is perhaps more difficult to produce or secure, as a rule, than is a good grade of alfalfa. By cutting it early and curing it with care, however, it should be possible to produce hay that would be satisfactory for pigs. Soybean hay is another possible substitute for alfalfa.

FEEDING MINERALS WITH THE TRIO MIXTURE

Feeding minerals with corn and the trio mixture was tried in three experiments. The mixture used in one test consisted of salt 19.4, limestone 77.6, and iron oxide 3; that used in the other two trials was the same except that 0.03 pound of potassium iodide was substituted for an equal amount of the iron oxide. Since, in tests with other supplements (34), the pigs sometimes failed to take

TABLE 12.—Effect of Feeding Minerals With Corn and the Trio Mixture

	1 Corn Tankage Linseed meal Ground alfalfa Salt	2 Corn Tankage Linseed meal Ground alfalfa **Minerals**
Number of experiments	3	3
Number of pigs	25	25
Initial weight per pig, lb.	53.7	53.5
Final weight per pig, lb.	211.0	213.0
Average daily gain, lb.	**1.07**	**1.16**
Days required to gain 160 lb.	150	138
Daily feed per pig, lb.:		
Corn	3.86	4.07
Tankage	.35	.35
Linseed meal	.17	.18
Ground alfalfa	.14	.15
Salt or minerals	.03—	.07
Total	**4.55—**	**4.82**
Feed per 100 lb. gain, lb.:		
Corn	360.89	352.38
Tankage	32.26	30.51
Linseed meal	16.13	15.25
Ground alfalfa	13.27	12.92
Salt or minerals	2.13—	6.29
Total	**424.68**	**417.35**
Cost of feed per 100 lb. gain	$ 7.50	$ 7.31

Lot 1: A 75.5-lb. pig was taken out after 56 days and a 92-lb. pig after 70 days, in one experiment; a 99.5-lb. pig was taken out after 70 days and two others weighing 118 and 122 lb., respectively, were taken out after 84 days in another experiment. These three were pneumonic.

Lot 2: An 89-lb. pig was taken out after 70 days in one experiment.

sufficient minerals to meet their needs when they were self-fed separately, in these trials the minerals were mixed with the other feeds at the rate of 1.4 to 1.6 per cent of the total ration. This averaged approximately one pound to every 10 pounds of the supplemental mixture of tankage, linseed meal, and ground alfalfa.

The differences were not great and were perhaps too small to be of significance, but, in each of the three experiments, both the rate of growth and the feed consumption per unit of gain were in favor of the pigs receiving minerals. With the other feeds at the prices used, and with only the feed required per unit of gain considered, the minerals showed an average replacement value, or a comparative worth, of 3.2 cents a pound. On the basis of these results, it would not pay to use high-priced minerals with a ration of corn and the trio mixture for the production of market hogs. The inexpensive mixture used, however, slightly reduced the cost of the gains and enabled the pigs receiving them to reach an average weight of 210 pounds 12 days earlier than those receiving no minerals other than salt. When corn and protein supplements of plant origin are fed, the need for minerals is more pronounced (37).

SKIMMED MILK AS A PARTIAL SUBSTITUTE FOR TANKAGE

Replacing a part of the tankage with skimmed milk was tried in three experiments. Groups of pigs given (1) corn and tankage, (2) corn, tankage, and skimmed milk, and (3) corn and the trio supplemental mixture were included in the tests. Each lot received salt. In one trial, a commercial grade of calcium carbonate was fed only with the first two supplements. In the others, ground limestone was included in all three rations. The practically pure calcium carbonate proved to be worth much less for feeding purposes than ground limestone, consisting largely of calcium carbonate but containing impurities, some of which, such as iron, were apparently beneficial. It was figured at the same price a pound as the limestone in determining the feed costs. The results of the three trials are summarized in Table 13.

Tankage and skimmed milk were superior to tankage alone for supplementing corn. With other feeds at the prices given, the skimmed milk, when used as a partial substitute for the tankage, showed the high comparative value of 62.8 cents per 100 pounds, or was worth 17.9 per cent as much as tankage. In five experiments in which skimmed milk was used as a complete substitute for tankage it was worth 33.1 cents per 100 pounds, or 9.5 per cent as much as tankage. Skimmed milk and tankage combined apparently give

better results than either used alone, or as the only supplement. In the trials in which it was used to replace a part of the tankage, the skimmed milk was fed at the average rate of a little less than a half gallon daily a head.

The pigs given the combination of skimmed milk and tankage not only did better than those given tankage as the only supplement but also gained 6 per cent more rapidly and required 9.9 per cent less dry matter per unit of gain than those given the trio mixture. With the ration containing it compared with the one containing the trio mixture, the skimmed milk showed a comparative feeding value of 52.3 cents per 100 pounds.

At the South Dakota Station (21) a combination of tankage and buttermilk was a more efficient supplement to yellow corn than either used alone.

RICE POLISH FOR FEEDING WITH CORN AND TANKAGE

Rice polish is the by-product of rice milling which is obtained in polishing the kernels after the hulls and bran have been removed. It contains approximately 12 per cent of protein and so would

TABLE 13.—Skimmed Milk Compared With Linseed Meal and Ground Alfalfa for Feeding With Corn and Tankage

	1 Corn Tankage	2 Corn Tankage **Skimmed milk**	3 Corn Tankage **Linseed meal** **Ground alfalfa**
Number of experiments	3	3	3
Number of pigs	23	24	24
Initial weight per pig, lb.	45.2	44.8	44.8
Final weight per pig, lb.	196.5	196.9	195.0
Average daily gain, lb.	**.96**	**1.19**	**1.12**
Days required to gain 150 lb.	157	126	134
Daily feed per pig, lb.:			
Corn	3.62	3.78	3.90
Tankage	.37	.22	.33
Skimmed milk	.....	3.23	.....
Linseed meal	.....	.....	.16
Ground alfalfa	.....	.....	.16
Minerals	.07	.07	.06
Total	**4.06**	**4.43***	**4.61**
Feed per 100 lb. gain, lb.:			
Corn	378.99	317.79	348.10
Tankage	38.80	18.84	29.81
Skimmed milk	.....	271.42	.....
Linseed meal	.....	.....	14.20
Ground alfalfa	.....	.....	14.34
Minerals	7.06	5.74	5.84
Total	**424.85**	**372.23***	**412.29**
Cost of feed per 100 lb. gain	$ 7.46	$ 6.73	$ 7.20

*With the skimmed milk reduced to 10 per cent moisture.
Lot 1: A 48-lb. pig was taken out after 91 days in one experiment.
Lot 2: A 36-lb. pig and a 54-lb. pig were taken out after 91 days in one experiment.
Lot 3: A 68-lb. pig was taken out after 68 days in one experiment.

classify as a medium- rather than as a high-protein feed. It is low in fiber, rich in phosphorus, palatable, and apparently highly nutritious. Since it gave excellent results when fed in rather limited quantities with corn, linseed meal, and minerals, it was tried with corn, tankage, and minerals. A summary of three experiments in which it was fed in this way is given in Table 14.

TABLE 14.—Adding Rice Polish to a Corn, Tankage, and Mineral Ration

	1 Corn Tankage Minerals	2 Corn **Rice polish** Tankage Minerals	3 Corn **Linseed meal** Tankage **Ground alfalfa** Minerals
Number of trials	3	3	3
Number of pigs	21	21	21
Initial weight per pig, lb.	50.2	49.6	50.3
Final weight per pig, lb.	199.9	199.4	199.9
Average daily gain, lb.	**1.05**	**1.20**	**1.23**
Days required to gain 150 lb.	143	125	122
Daily feed per pig, lb.:			
Corn	3.72	3.60	3.98
Rice polish	.....	.41	.....
Tankage	.38	.38	.32
Linseed meal	.....	.....	.15
Ground alfalfa	.....	.....	.16—
Minerals	.06	.06	.04
Total	**4.16**	**4.45**	**4.65**
Feed per 100 lb. gain, lb.:			
Corn	352.55	301.39	324.30
Rice polish	.....	34.22	.....
Tankage	36.26	32.19	26.23
Linseed meal	.....	.....	12.37
Ground alfalfa	.....	.....	12.48
Minerals	5.92	4.78	3.00
Total	**394.73**	**372.58**	**378.38**
Cost of feed per 100 lb. gain	$ 6.95	$ 6.60	$ 6.61

The rice polish made up 10 per cent of the total ration in one experiment and was fed at the same rate as the tankage in the other two. The minerals used consisted of salt and a commercial grade of calcium carbonate in one trial and of salt and limestone in the others.

The rapidity of the gains made by the pigs receiving rice polish and those receiving the trio mixture were practically the same in one trial and slightly in favor of those getting the trio mixture in the other two. In the three tests the pigs given the rice polish required 24 and 9 pounds less and 4 pounds more feed, respectively, for each 100 pounds of gain than did those given the trio mixture. Thus, the inclusion of rice polish in a mixture of corn, tankage, and minerals improved the ration and made it fully as effective as, if not slightly more effective than, the one of corn, tankage, linseed meal, ground alfalfa, and minerals.

COTTONSEED MEAL AS A SUBSTITUTE FOR LINSEED MEAL IN THE TRIO MIXTURE

Cottonseed meal is produced in much greater abundance and is usually lower in price than is linseed meal. Some cottonseed meals prove toxic to pigs, if they are used as the only protein concentrate and are fed in sufficient quantities to supply the protein needed to balance corn for dry-lot feeding. No harmful effects have resulted, however, from feeding cottonseed meal in the place of linseed meal in the trio supplemental mixture. When fed in this way the cottonseed meal ordinarily makes up from 3 to 5 per cent, or only a relatively small amount, of the total ration. In tests at the Ohio Station (36), cottonseed meal that caused deaths, when making up 18 per cent of the ration and used as the only protein concentrate, produced no harmful effects when fed at a 20 per cent level in a similar ration to which 8 per cent of tankage was added. Table 15 gives the average results of three trials in which cottonseed meal was substituted for linseed meal in the trio mixture.

TABLE 15.—Cottonseed Meal Substituted for Linseed Meal in the Trio Mixture

	1 Corn Tankage **Linseed meal** Ground alfalfa Minerals	2 Corn Tankage **Cottonseed meal** Ground alfalfa Minerals
Number of experiments	3	3
Number of pigs	28	28
Initial weight per pig, lb	52.8	52.3
Final weight per pig, lb	221.9	219.5
Average daily gain, lb	**1.24**	**1.18**
Days required to gain 170 lb	137	144
Daily feed per pig, lb.:		
Corn	4.09	4.06
Tankage	.37	.35
Linseed or cottonseed meal	.18	.17
Ground alfalfa	.16	.15
Minerals	.06	.06
Total	**4.86**	**4.79**
Feed per 100 lb. gain, lb.:		
Corn	330.07	342.90
Tankage	29.70	29.51
Linseed or cottonseed meal	14.85	14.75
Ground alfalfa	12.55	12.72
Minerals	4.72	4.90
Total	**391.89**	**404.78**
Cost of feed per 100 lb. gain	$ 6.92	$ 7.09

No minerals other than salt were fed in one of the three experiments.

Lot 1: An 83.5-lb. pig and a 66.5-lb. one were taken out after 98 days in one experiment.

Lot 2: A 93.5-lb. pig was taken out after 56 days in one experiment and a 49-lb. pig after 70 days in another.

The rations containing cottonseed meal failed to produce quite as rapid gains or as much gain from a given amount of feed as did those containing linseed meal. The amounts of cottonseed meal fed ranged from 3.8 to 4.8 per cent of the total feed while the pigs were under 120 pounds in weight, and from 2.8 to 3.4 per cent after the 120-pound weight was reached.

Substituting cottonseed meal for linseed meal in the trio mixture was also tried by the Iowa (13, 14), Illinois (5), Nebraska (24), and Kansas (2) Stations. A summary of these and of the Ohio trials, including a total of eight experiments, shows that the pigs receiving linseed meal and those receiving cottonseed meal made average gains of 1.38 and 1.36 pounds daily a head and consumed an average of 411.2 and 409.4 pounds of feed, respectively, for each 100 pounds of gain. This is a difference of only 1.3 per cent in the rate of growth and of less than a half of a per cent in the feed required per unit of gain. With feeds so nearly equal in effectiveness, which to use would be determined largely by their relative prices.

OATS IN A CORN, TANKAGE, AND ALFALFA RATION

Oats are available on many farms for the feeding of hogs. Frequently, their price is relatively low as compared with that of corn. Due to the presence of the hulls, oats are too bulky to be suitable for making up a large share of the ration for growing and fattening pigs. They may be fed in smaller amounts with satisfactory results. Table 16 summarizes two experiments in which a ration of corn, oats, tankage, alfalfa, and minerals was compared with one composed of the same feeds without the oats, as well as a similar one containing linseed meal but no oats. All of the feeds were mixed and self-fed. Ground oats were used in one experiment and whole oats in the other. They were fed at a rate which approximated 2 pounds for each pound of the mixture of tankage, ground alfalfa, and minerals.

Oats may be fed in various ways. One of these is to place the corn, the oats, and the supplemental mixture in separate compartments of a self-feeder and allow the pigs to take whatever they care for of each. When they are fed in this way, the pigs sometimes take an almost negligible quantity of oats (15). Possibly the oat consumption could be increased by self-feeding the oats and supplement separately and feeding the corn twice daily. Another method is to feed definite proportions of corn and oats. This can easily be done if the corn is ground, but under usual conditions it does not

pay to shell and grind the corn for pigs. If ear corn is fed, as is ordinarily advisable, it is easier to feed the oats and supplement in definite proportions than it is to estimate the consumption of corn, make allowance for the cob, and then use a pound of oats for every so many pounds of corn. A mixture of ground oats and supplement is suitable for self-feeding, or for feeding at a given rate daily a head.

TABLE 16.—Oats for Feeding With Corn, Tankage, Ground Alfalfa, and Minerals

	1 Corn Tankage Ground alfalfa Minerals	2 Corn Tankage **Linseed meal** Ground alfalfa Minerals	3 Corn **Oats** Tankage Ground alfalfa Minerals
Number of trials	2	2	2
Number of pigs	16	16	16
Initial weight per pig, lb.	51.4	51.3	50.6
Final weight per pig, lb.	190.5	185.2	190.3
Average daily gain, lb.	**1.07**	**1.11**	**1.14**
Days required to gain 150 lb.	140	135	132
Daily feed per pig, lb.:			
Corn	3.92	3.79	3.20
Oats			1.21
Tankage	.47	.36	.39
Linseed meal		.18	
Ground alfalfa	.14	.14	.15
Minerals	.07	.07	.07
Total	**4.60**	**4.54**	**5.02**
Feed per 100 lb. gain, lb.:			
Corn	365.07	342.94	280.94
Oats			105.92
Tankage	43.41	32.65	33.95
Linseed meal		16.32	
Ground alfalfa	12.83	12.31	13.22
Minerals	6.42	6.16	6.61
Total	**427.73**	**410.38**	**440.64**
Cost of feed per 100 lb. gain	$ 7.64	$ 7.27	$ 7.44

Lot 1: A 72-lb. pig was taken out after 84 days in one experiment, and a 76-lb. pig after 70 days and a 108.5-lb. pig after 84 days in the other experiment.
Lot 2: An 89.5-lb. pig was taken out after 70 days in one experiment.

While they are young, pigs can utilize a somewhat larger percentage of oats in the ration to advantage than they can when they are approaching market maturity. As they get older, pigs also need a larger percentage of carbohydrates and a smaller percentage of protein in their ration. Proportioning the oats on the basis of the supplement automatically reduces the percentage in the ration as the pigs become heavier and makes possible the utilization of a slightly larger average amount than would otherwise be advisable.

The oats used in the experiments reported in Table 16 averaged 24 per cent of the total ration, or 1 pound for every 2.65 pounds of corn. Fed at this rate their inclusion in a ration otherwise the same increased rather than reduced the rate of growth. While the

pigs receiving the oats required more total feed per unit of gain, the difference was apparently due to the greater fiber content of the ration as a result of the presence of the oat hulls. On a fiber-free basis the difference was only 3 pounds for each 100 pounds of gain.

The ration of corn, the trio mixture, and minerals was more effective than the one containing oats but no linseed meal. Again, at least a part of the difference was probably due to the hulls or the higher fiber content of the ration containing oats. Oats weighing 32 and 33 pounds to the bushel, respectively, were used in the two experiments. The weight of the hulls was not determined in the first but was 26.7 per cent of the total weight of the oats in the second experiment. On a hull-free basis, with this figure used, the pigs getting oats required 412.4 pounds of feed for each 100 pounds of gain, or practically the same amount as was required by the pigs receiving the trio mixture and no oats.

OATS AND HULLED OATS FOR FEEDING WITH CORN AND THE TRIO MIXTURE

In the two experiments summarized in Table 17, linseed meal was included in the ration regardless of whether oats were or were not fed. The oats used averaged 23.5 per cent of the ration, or 1 pound for every 2.6 pounds of corn. Two pounds for every pound of supplement, exclusive of the minerals, were fed in one trial and 1.5 pounds for every pound of supplement, including the minerals, in the other. The pigs getting no oats were ready for market 5 days earlier and made more gain from a given amount of feed than those receiving oats. The difference in the efficiency of the rations corresponded closely to that in the tests reported in Table 16.

At the prices used, the average amounts of other feeds replaced by ground oats, in five trials, when limited quantities were included in a corn and supplement ration showed the oats to be worth 85 per cent as much a pound as the corn. Inasmuch as higher relative values were obtained for oats in similar tests at the Illinois (7, 8, 9, 10) and Indiana (42) Stations, if this figure is not approximately correct, it is probably low rather than high. As previously mentioned, oats are worth less when they make up a large share of the ration.

Hulled oats were fed to a third group of pigs in the two trials reported in Table 17. Commercial hulled oats were used in one of the tests and oats hulled with a farm-type huller in the other. The amount fed approximated 1.5 pounds for each pound of supplement.

The inclusion of hulled oats in the ration increased the rapidity of the gains 4.4 per cent and lowered the feed consumed per unit of gain 2.8 per cent.

TABLE 17.—Oats and Hulled Oats, Fed With Corn, the Trio Mixture, and Minerals

	1 Corn Tankage Linseed meal Ground alfalfa Minerals	2 Corn **Oats** Tankage Linseed meal Ground alfalfa Minerals	3 Corn **Hulled oats** Tankage Linseed meal Ground alfalfa Minerals
Number of experiments	2	2	2
Number of pigs	24	22	22
Initial weight per pig, lb.	59.4	59.9	60.3
Final weight per pig, lb.	203.4	205.3	204.1
Average daily gain, lb.	**1.13**	**1.09**	**1.18**
Days required to gain 150 lb.	133	138	127
Daily feed per pig, lb.:			
Corn	3.80	2.92	2.96
Oats	.....	1.11	.....
Hulled oats	.....	.....	1.03
Tankage	.39	.33	.33
Linseed meal	.19	.17	.16
Ground alfalfa	.14	.14	.14
Minerals	.06	.06	.06
Total	**4.58**	**4.73**	**4.68**
Feed per 100 lb. gain, lb.:			
Corn	337.27	266.95	250.10
Oats	.....	101.55	.....
Hulled oats	.....	.....	86.77
Tankage	34.43	30.03	27.40
Linseed meal	17.21	15.02	13.70
Ground alfalfa	12.19	12.96	11.85
Minerals	5.41	5.63	5.41
Total	**406.51**	**432.14**	**395.23**
Cost of feed per 100 lb. gain	$ 7.25	$ 7.49	$ 7.67

Because of the loss of approximately a third of the original weight, hulled oats are a relatively expensive feed. In determining the feed cost per 100 pounds of gain, as given in the table, the price assigned the hulled oats was arrived at by estimating the quantity of whole oats required to produce them and adding to the cost of the whole oats a charge of 20 cents per 100 pounds for hulling. This price would be applicable to oats hulled at home, or by some one doing custom hulling, if the hulls were not taken into consideration. Commercial hulled oats, produced by rolled oats mills or breakfast food manufacturers, would ordinarily cost more in relation to the price of corn. Since they are made from high-quality oats and are free from hulls, possibly their feeding value would be slightly higher than that of home- or custom-hulled oats, which, as a rule, are not entirely free from hulls.

At the prices used, hulled oats were not an economical feed. Their feeding value, however, was 24.3 per cent greater than that of an equal weight of corn. With oats costing 42 instead of 44

cents a bushel, the feed cost per 100 pounds of gain would have been the same for the pigs receiving the hulled oats as for those receiving the same ration without oats. Stated differently, if the price of oats had not exceeded 88 per cent of that of corn a pound, it would have paid to feed hulled oats.

Oat hulls have some nutritive value for animals which can utilize more bulky rations to advantage. Assuming that their value would offset the hulling charge, the cost of the unground hulled oats would be reduced to $2.07 per 100 pounds. This, in turn, would lower the feed cost per 100 pounds of gain for the pigs given ground hulled oats from $7.67 to $7.41.

The Illinois (7, 8) and Indiana (42) Stations have also tried feeding hulled oats with corn and the trio mixture to pigs in dry lot, with somewhat similar results. The pigs getting hulled oats ordinarily gained more rapidly and made greater gains from a given amount of feed.

HULLED OATS WITH LINSEED MEAL OMITTED FROM THE RATION

Table 18 summarizes two experiments in which a ration of corn, the trio mixture, and minerals was compared with a similar one containing commercial hulled oats but having the linseed meal omitted.

TABLE 18.—Comparison of Hulled Oats and Linseed Meal When Fed With Corn, Tankage, Ground Alfalfa, and Minerals

	1 Corn **Linseed meal** Tankage Ground alfalfa Minerals	2 Corn **Hulled oats** Tankage Ground alfalfa Minerals
Number of trials	2	2
Number of pigs	15	14
Initial weight per pig, lb.	52.5	52.8
Final weight per pig, lb.	218.5	215.9
Average daily gain, lb.	**1.29**	**1.38**
Days required to gain 170 lb.	132	123
Daily feed per pig, lb.:		
Corn	4.25	3.95
Hulled oats	.....	.49
Tankage	.37	.44
Linseed meal	.19	.....
Ground alfalfa	.16	.18
Minerals	.07	.08
Total	**5.04**	**5.14**
Feed per 100 lb. gain, lb.:		
Corn	330.17	285.96
Hulled oats	.....	35.55
Tankage	28.58	31.94
Linseed meal	14.29	.....
Ground alfalfa	12.34	12.74
Minerals	5.63	5.37
Total	**391.01**	**371.56**
Cost of feed per 100 lb. gain	$ 6.86	$ 6.84

Equal parts of hulled oats and tankage were fed in one trial to its close and in the other until the pigs averaged 120 pounds in weight, after which 1.5 times as much hulled oats as tankage was used. Besides gaining more rapidly and being ready for market 9 days earlier, the pigs given hulled oats required less feed per unit of gain than those given linseed meal. At the prices used, there was practically no difference in the cost of the gains. Based on the assumption that the value of the hulls would offset the hulling charge, the feed cost per 100 pounds of gain would have been 13 cents lower for the pigs given hulled oats than for those given linseed meal. Each 100 pounds of ground hulled oats replaced $2.56 worth of other feed. Thus, the feeding value of the hulled oats was 60 per cent greater a pound than that of corn, but the amount utilized was small. Possibly, also, home-hulled oats would have shown a somewhat lower value.

OMITTING LINSEED MEAL WHEN OATS ARE INCLUDED IN THE RATION

The omission of linseed meal from the trio mixture when oats were included in the ration was tried in the experiments reported in Table 19. A pound and a half of oats to each pound of supplement were used in the ration containing linseed meal in one experiment to its close, and in the other until the pigs averaged 125 pounds in weight, when the amount was changed to 1.2 pounds for each pound of supplement. The pigs receiving no linseed meal were also fed 1.5 pounds of oats for each pound of supplement throughout the test, in one trial. Before and after they reached the 125-pound weight, the pigs in the other trial were fed 2 and 1.5 pounds of oats for each pound of supplement, respectively.

The differences were small but in both experiments the rapidity of the gains was slightly in favor of the ration containing linseed meal. The feed consumption per unit of gain was almost exactly the same on the two rations, having been a trifle lower for one in the first experiment and for the other in the next. Unless it is a slight increase in palatableness or in the amount of feed consumed, apparently little is gained by including linseed meal in the ration when oats are fed.

TABLE 19.—Omitting Linseed Meal from the Ration When Oats are Fed

	1 Corn Oats Tankage Ground alfalfa Minerals	2 Corn Oats Tankage **Linseed meal** Ground alfalfa Minerals
Number of experiments	2	2
Number of pigs	22	22
Initial weight per pig, lb.	64.5	64.2
Final weight per pig, lb.	205.1	205.8
Average daily gain, lb.	**1.04**	**1.09**
Days required to gain 150 lb.	144	138
Daily feed per pig, lb.:		
Corn	3.10	3.12
Oats	1.01	1.08
Tankage	.43	.36
Linseed meal	.....	.18
Ground alfalfa	.14	.15
Minerals	.07	.06
Total	**4.75**	**4.95**
Feed per 100 lb. gain, lb.:		
Corn	298.40	287.42
Oats	97.56	99.54
Tankage	41.66	32.93
Linseed meal	.....	16.47
Ground alfalfa	13.72	13.68
Minerals	6.10	6.06
Total	**457.44**	**456.10**
Cost of feed per 100 lb. gain	$ 8.01	$ 7.93

Lot 1: A 91.5-lb. pig was taken out after 41 days in one experiment.

ADDING WHEAT MIDDLINGS TO A CORN AND TANKAGE RATION

Wheat middlings are often fed with corn and tankage to pigs. Table 20 summarizes three experiments in which rations of corn and tankage, and of corn, middlings, and tankage were compared for dry-lot feeding. The pigs in two of the comparisons were carried from approximately 72 to 228 pounds in weight. The data in the other comparison were for a period of 10 weeks. In one trial, the feeds were self-fed; in the other two, the feeds were mixed and fed in troughs twice daily. Flour middlings were used.

The summary of the three trials shows practically no difference in either the rate of growth or in the total amount of feed required per unit of gain. Since middlings are higher in protein than corn, less tankage was used when they were included in the ration. Because of the saving in tankage the pigs getting middlings made the cheaper gains.

As mentioned above, the data for one trial were summarized for a period of 10 weeks. The test was continued for a longer time, but by the end of the fourteenth week four pigs out of the eight receiving corn, middlings, and tankage were stiff or crampy; that

is, showed symptoms of rickets. From the twelfth to the fourteenth week, all four of these pigs lost rather than gained in weight.

TABLE 20.—Wheat Middlings for Feeding With Corn and Tankage

	1 Corn Tankage	2 Corn Middlings Tankage
Number of experiments	3	3
Number of pigs	20	22
Initial weight per pig, lb.	80.7	80.4
Final weight per pig, lb.	213.3	211.8
Average daily gain, lb.	**1.34**	**1.35**
Days required to gain 135 lb.	101	100
Daily feed per pig, lb.:		
Corn	5.13	4.20
Middlings		1.17
Tankage	.49	.31
Total	**5.62**	**5.68**
Feed per 100 lb. gain, lb.:		
Corn	381.52	311.00
Middlings		87.13
Tankage	36.87	23.05
Total	**418.39**	**421.18**
Cost of feed per 100 lb. gain	$ 7.39	$ 7.18

In eleven dry-lot experiments, at five different stations (17, 19, 25, 31, 33), with pigs having average initial weights of 75 pounds or less, those fed corn and tankage gained 1.19 pounds daily whereas those fed corn, middlings, and tankage gained 1.26 pounds daily. The tests included a total of 114 pigs on corn and tankage and 116 on corn, middlings, and tankage. As named, their average initial weights were 62.9 and 63.2 pounds and their final weights 210.9 and 215.8 pounds, respectively. Minerals were fed in two of the eleven trials. The pigs given corn and tankage required averages of 386.6 pounds of corn, 40.5 pounds of tankage, and .7 pounds of minerals, or a total of 427.8 pounds of feed for each 100 pounds of gain. The others required 326.1 pounds of corn, 83.8 pounds of middlings, 32.6 pounds of tankage, and .7 pound of minerals, or a total of 443.2 pounds of feed for each 100 pounds of gain.

Middlings increased the rate of growth 6.4 per cent, or enabled the pigs getting them to be marketed 7 days earlier, but did not increase the gains from a given amount of feed. Considering only the feed requirement per unit of gain, the other feeds replaced by the middlings, at the prices listed, would give the middlings a value of $29.64 a ton, or 92.6 per cent that of an equal weight of corn.

PALMO MIDDS, COCOANUT OIL MEAL, AND COCOA BEAN OIL MEAL

Flour middlings, standard middlings, Palmo Midds, cocoanut oil meal, cocoa bean oil meal, and linseed meal were compared for feeding with corn, tankage, ground alfalfa, and minerals in the experiment reported in Table 21. The minerals consisted of one pound of salt to 2 pounds of limestone and made up 1.5 per cent of the ration. The ground alfalfa was fed at the rate of 2 pounds for each 100 pounds of total feed. Half as much linseed meal as tankage was fed. Fifteen per cent of flour middlings and cocoanut oil meal and 18 per cent of standard middlings and Palmo Midds were included in their respective rations. The tankage was varied so as to provide nutritive ratios of approximately 1:5.7 until the pigs averaged 120 pounds in weight and 1:6.3 thereafter.

Palm oil is used to polish tin plate during the process of its manufacture and middlings are employed to absorb the oil. After they are no longer useful for this purpose they are cleaned in such a way as to remove any harmful materials and sold as Palmo Midds for feeding purposes.

The standard middlings fed in the experiment were obtained from the same company that supplied the Palmo Midds and were of the same character as those used in the manufacture of Palmo Midds.

Cocoanut oil meal is the ground residue left after a part of the oil has been extracted from the dried meat of the cocoanut. That used in the experiment had been stored in a barn loft for a year but no rancidity could be observed, and the meal had apparently not deteriorated in palatability.

Cocoa, or cacao, bean oil meal is the ground product resulting after the oil or "cocoa butter" has been pressed from cocoa seeds for the manufacture of chocolate. The composition of these less common products, as well as of the two grades of middlings used in the experiment, is given in Table 22.

Adding middlings to the ration and omitting linseed meal from the supplemental mixture apparently lowered, rather than increased, its efficiency. When fed in this way, and the ration containing them was compared with the one of corn and the trio mixture, flour middlings were worth 84.2 per cent as much as an equal weight of ground corn. Although the amounts of feed required per unit of gain were not greatly different, the standard middlings had a lower replacement or feeding value than the flour middlings. Possibly the difference in value was influenced somewhat by the

TABLE 21.—Wheat Middlings, Palmo Midds, Cocoanut and Cocoa Bean Oilmeals for Pigs

	1	2	3	4	5	6
	Corn; tankage; ground alfalfa; minerals					
	Linseed meal	**Flour middlings**	**Standard middlings**	**Palmo Midds**	**Cocoanut oil meal**	**Cocoa bean oil meal**
Number of pigs	6	6	6	6	6	6
Initial weight per pig, lb.	65.1	65.4	65.1	65.1	64.8	65.0
Final weight per pig, lb.	200.4	211.9	207.7	203.1	205.1	201.7
Average daily gain, lb.	**1.07**	**.99**	**1.07**	**1.10**	**1.11**	**.49**
Days required to gain 150 lb.	140	152	140	137	135	306
Daily feed per pig, lb.:						
Corn	3.68	3.17	3.31	3.28	3.44	2.38
Medium protein feed	.14	.62	.82	.81	.67	.37
Tankage	.29	.21	.25	.27	.21	.17
Ground alfalfa	.09	.08	.09	.09	.09	.06
Minerals	.06	.06	.07	.07	.07	.04
Total	**4.26**	**4.14**	**4.54**	**4.52**	**4.48**	**3.02**
Feed per 100 lb. gain, lb.:						
Corn	342.66	319.60	309.04	299.09	309.06	488.36
Medium protein feed	13.31	62.74	76.14	74.26	60.42	75.57
Tankage	26.62	21.30	23.02	24.77	19.20	34.94
Ground alfalfa	7.93	8.37	8.46	8.25	8.05	12.41
Minerals	5.95	6.27	6.35	6.19	6.04	9.31
Total	**396.47**	**418.28**	**423.01**	**412.56**	**402.77**	**620.59**
Cost of feed per 100 lb. gain	$ 6.88	$ 7.04	$ 6.99	$ 6.87	$ 6.83	$10.51

Lot 2: A 95-lb. pig was taken out after 70 days.
Lot 6: An 81-lb. pig was taken out after 70 days.

slightly larger percentage of standard middlings fed, but, in view of their higher fiber content, the lower feeding value of the standard middlings is not surprising.

Two trials comparing flour and standard middlings for feeding with corn and tankage to pigs on alfalfa pasture were conducted by Ferrin and McCarty (18). Both the flour and standard middlings made up 30 per cent of their respective rations until the pigs averaged 100 pounds in weight and 23 per cent of the ration thereafter. With ground corn at 1.6 and tankage at 3.5 cents a pound, the flour middlings were worth 18.4 per cent more than the standard middlings, according to the results of these tests. The difference in feeding value, on a percentage basis, would vary somewhat, of course, with changes in the relative prices of corn and tankage or the feeds replaced.

Although the daily feed consumption was practically the same, the pigs receiving the Palmo Midds gained more rapidly and required less feed per unit of gain than those receiving the standard middlings. With the Palmo Midds fed at the level used, the presence of the palm oil apparently increased rather than decreased the worth of the middlings for feeding purposes. In an earlier test, however, in which they were fed at a higher, or 25 per cent, level Palmo Midds made a much poorer showing than wheat middlings, fed at the same level. The ration containing 25 per cent of Palmo Midds along with ground corn and tankage, proved unpalatable to pigs not accustomed to their taste. Thus, Palmo Midds have shown a higher value when fed in relatively small amounts than when making up a larger share of the ration.

Cocoanut meal was satisfactory as a feed for pigs. The ration containing it produced slightly faster growth, although hardly as much gain per unit of feed as the one containing linseed meal. Not considering the faster growth but only the feed required per unit of gain, the feeding value of cocoanut oil meal, in this test, was 13.2 per cent greater than that of an equal weight of ground corn. Because of its fibrous character, the use of a high percentage of cocoanut oil meal in the ration would not be advisable.

Cocoa bean oil meal proved unsuitable for pigs. For the first 22 weeks of the experiment, it was fed at a 15 per cent level. During this period, the pigs ate very little more feed than was necessary for maintenance and made an average gain of only .26 pound daily a head. One died on the 91st day of the trial, apparently as a result of the ration received. The others all became unthrifty in appearance. At the beginning of the 23rd week, the cocoa bean oil

meal was reduced to 10 per cent of the ration. Although no further losses occurred and the pigs did not do as poorly from then on as previously, the ration was still an unsatisfactory one.

Alpin (1) fed a ration containing 15 per cent of cocoa bean oil meal to pigs, 10 weeks of age at the beginning of the test, for a period of 22 days. They refused to eat normal quantities of feed, scoured some, became generally unthrifty, and made an average gain of only 1.3 pounds each in the entire time of 22 days. Two of the pigs died a few days later, after the feeding of cocoa bean oil meal had been discontinued. Sows fed a ration containing 15 per cent of cocoa bean oil meal likewise failed to make satisfactory gains.

Cocoa bean oil meal contains small amounts of theobromin and of caffein, which are alkaloids of similar character. According to manufacturers, the theobromin content ranges from 1 to 2.9, and averages about 2, per cent; whereas the caffein content averages about .75 per cent. Hansen (20) fed both cocoa bean oil meal and theobromin to fowls, rabbits, and mice and concluded that the theobromin in the cocoa bean oil meal was the cause of its injurious effect.

TABLE 22.—Composition of Intermediate Feeds Used in Experiment Reported in Table 21

	Water	Ash	Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free extract	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Flour middlings	8.70	3.91	15.56	4.45	63.98	3.40
Standard middlings	8.20	4.38	15.75	6.21	59.21	6.25
Palmo Midds	7.08	4.53	14.44	7.03	57.14	9.78
Cocoanut oilmeal	9.10	8.10	19.00	13.23	30.04	20.53
Cocoa bean oilmeal	8.50	6.10	22.25	10.02	31.12	21.31

DRY-RENDERED TANKAGE

Within comparatively recent years a system of making tankage by a dry-rendering process has been developed. In the older, or steam-rendering, method, the material is cooked at high temperatures with steam under pressure. The products resulting from the cooking are melted fats, solids, and a liquid, or liquor. The solid matter is pressed to remove as much of the remaining fat as possible, is then dried, and is finally ground for tankage. The liquor is high in protein, on a moisture-free basis, but contains around 96 per cent of water. In the larger plants it is drawn off and reduced in moisture content to about 50 per cent, when it

becomes a thick, gluey substance which is known as liquid stick. This is added to the pressed solids before drying and together with dried blood is used to bring the protein content of the final product up to the standard 60 per cent.

In the dry-rendering process the material is hashed or ground to reduce it to small-sized pieces. It is then cooked, without the addition of water, in a steam-jacketed, horizontal tank, or melter, which is equipped with agitators to keep the material stirred, thus preventing scorching, permitting the gases and moisture to pass off more readily, facilitating heat penetration, and reducing the time required for cooking. The moisture driven out of the material by cooking is either carried off through a vent connected to the melter or drawn off by vacuum. From the melter, the material is discharged into a tank having a perforated false bottom, which allows the melted fat to drain away. The residue is then pressed, usually in a screw-type, continuous press, or expeller, to remove as much of the remaining fat as possible and is finally ground.

Crackling, or dry-rendered tankage, unlike steam-rendered tankage, is practically non-odorous. It is also lighter in color. Since no water is added and steam does not come in contact with the material, none of the ammonia or protein is washed out. Consequently, dry-rendered tankage is higher in protein than is the wet, or steam-rendered, product. That used in the experiment reported in Table 23 contained 69.3 per cent of protein. For poultry feeding, bone is usually mixed with the dry-rendered material to form meat and bone scraps, containing approximately 50 per cent of protein.

Dry- and steam-rendered tankages were compared for feeding with corn and minerals and also for feeding with corn, linseed meal, ground alfalfa, and minerals. The rations were mixed and self-fed, and the two types of tankage were fed on an equivalent protein basis. Until the pigs, receiving the mixture of corn, tankage, and minerals, averaged 120 pounds in weight, the steam- and dry-rendered tankages made up 11.8 and 10.2 per cent of their respective rations. Thereafter, as named, they made up 7.9 and 6.8 per cent of the rations. When used in connection with linseed meal and ground alfalfa, the two kinds of tankage constituted 9.2 and 8 per cent of their respective rations at first and 6.0 and 5.4 per cent of the total feed after average weights of 120 pounds were reached.

The dry-rendered tankage proved more palatable than the ordinary tankage. In both comparisons the pigs getting the dry-rendered product required less feed per unit of gain than the others. As determined from the value of the other feeds replaced per unit of gain and as compared with steam-rendered tankage at

$70.00 a ton, the dry-rendered tankage had an average worth of $89.71 a ton. This would make the protein in it worth approximately 11 per cent more a pound than that in the ordinary tankage, or, if both contained 60 per cent of protein, it would make the dry-rendered tankage worth approximately $7.67 more a ton than the steam-rendered tankage. In a trial with pigs on rape pasture (38), the protein in dry-rendered tankage was worth approximately 15 per cent more a pound than that in the steam-rendered tankage. Comparisons by Loeffel (25, 26) and by Culbertson and Hammond (11) also showed dry-rendered to be superior to steam-rendered tankage.

Regardless of whether steam-rendered or dry-rendered tankage was fed, the ration was improved by the addition of a little linseed meal and ground alfalfa.

TABLE 23.—Comparison of Steam- and Dry-Rendered Tankages

Experiment started Dec. 5, 1928 Pigs self-fed indoors	1 Corn Tankage Minerals	2 Corn **Dry-rendered tankage** Minerals	3 Corn Tankage Linseed meal Ground alfalfa Minerals	4 Corn **Dry-rendered tankage** **Linseed meal** **Ground alfalfa** Minerals
Number of pigs	8	8	8	8
Initial weight per pig, lb.	54.5	55.1	54.4	54.8
Final weight per pig, lb.	194.9	175.6*	196.1	193.5
Average daily gain, lb.	**1.02**	**.91**	**1.08**	**1.20**
Days required to gain 150 lb.	147	165	139	125
Daily feed per pig, lb.:				
Corn	4.17	3.68	3.96	4.14
Tankage	.47	.36	.35	.33
Linseed meal			.18	.17
Ground alfalfa			.14	.15
Minerals	.07	.07	.07	.09
Total	**4.71**	**4.11**	**4.70**	**4.88**
Feed per 100 lb. gain, lb.:				
Corn	409.56	406.07	367.49	344.61
Tankage	46.45	39.24	32.80	27.69
Linseed meal			16.40	13.84
Ground alfalfa			13.09	12.17
Minerals	6.94	8.16	6.54	7.30
Total	**462.95**	**453.47**	**436.33**	**405.61**
Cost of feed per 100 lb. gain	$ 8.24	$ 8.16	$ 7.66	$ 7.49

*The hogs in this experiment were shipped to Kenton, Ohio, on April 19; hence, this lot had to be discontinued before they reached a final weight comparable with that of the others. At the time the pigs of Lot 1 averaged 165 pounds in weight they had consumed 459.4 pounds of feed for each 100 lb. of gain.

Lot 1: A 104-lb. pig was taken out after 84 days.
Lot 3: An 89-lb. pig was taken out after 70 days.
Lot 4: A 111-lb. pig was taken out after 70 days.

SUMMARY

Feeding 1 to 1.5 per cent of limestone in a corn and tankage ration to pigs confined indoors increased the rapidity of the gains and lowered the feed consumption per unit of gain.

Groups of pigs receiving mineral mixtures containing a small percentage of copperas, of iron oxide, or of Glauber's salts made faster gains and greater gains per unit of feed than others on similar rations without its addition. Since each was tried in only one experiment, the data are not regarded as conclusive.

The differences in the rate of growth and in the feed required per unit of gain of pigs given minerals of salt and limestone and of salt, limestone, and bone meal were less than 1.5 per cent. Thus, the limited data obtained indicated that a ration containing 7.5 per cent of tankage was not deficient in bone or phosphorus.

Fermenting the feed with yeast had little or no effect on the rapidity of growth or on the gain produced from a given amount of feed. The use of commercial yeast at 70 cents a pound increased the cost of the gains 49 cents per 100 pounds. Self-propagated yeast was practically as effective as commercial yeast; hence, even if it paid to ferment the feed with yeast it would not be necessary to buy any more high-priced commercial yeast than that needed for use as a "starter."

When corn, tankage, linseed meal, and minerals were fed, pigs which were allowed to run out in the sunlight made faster gains and greater gains per unit of feed in one trial, but not in another, than pigs confined indoors.

Cod-liver oil increased the efficiency of a corn and tankage ration. Pigs given aerated cod-liver oil, supposedly having its vitamin-A, but not its vitamin-D, content destroyed, made as much gain per unit of feed but did not gain as rapidly as those given untreated cod-liver oil.

Corn and tankage were improved by the addition of a little linseed meal and ground alfalfa. Neither linseed meal nor ground alfalfa alone was as beneficial as was a combination of the two.

Ground alfalfa, fed with corn, tankage, linseed meal, and minerals, at the average rate of 3.5 pounds to each 100 pounds of total feed, brought about as much saving in feed per unit of gain as did the use of cod-liver oil.

A summary of nine trials shows that including a little linseed meal and ground alfalfa in a corn and tankage ration increased the rapidity of the gains an average of 21.3 per cent and lowered the feed consumption per unit of gain 5 per cent. Considering only the

feed consumption per unit of gain, the supplemental mixture of tankage, linseed meal, and ground alfalfa was worth 99 per cent as much as a supplement of tankage alone, which is considerably higher in protein.

Whole alfalfa hay, kept before the pigs in a rack, gave as good results, in the one test in which it was tried, as ground alfalfa, mixed with the other feeds. Bright green, leafy hay of excellent quality was used. When ground, the hay can be mixed with the other feeds and the pigs forced to take a given quantity.

Chopped clover of high quality was equal in feeding value to chopped alfalfa of a similar grade. Presumably, soybean and other leguminous hays could likewise be substituted for the alfalfa, providing they were leafy and of good quality.

Adding minerals to corn and the trio mixture was tried in three experiments. The pigs given minerals were ready for market 12 days earlier, on the average, than those receiving no additional minerals, other than salt. The feeds replaced by the minerals, per unit of gain, showed them to have a comparative feeding value of 3.2 cents a pound. The worth of minerals, for use with corn and the trio mixture, was thus much less than their worth for use with rations made up of grains and protein feeds of plant origin.

A combination of skimmed milk and tankage was superior to the trio mixture, as well as to tankage alone, for supplementing corn. Fed as the only supplement, skimmed milk was worth about one-tenth as much a pound as tankage. Fed as a partial substitute, or in small quantities along with tankage, its feeding value was 18 per cent that of tankage. It was used at an average rate of a little less than a half gallon daily per head.

Rice polish, fed with corn, tankage, and minerals, at about the same rate as the tankage, improved the ration and made it fully as, if not slightly more, efficient than one of corn, the trio mixture, and minerals.

Cottonseed meal was a satisfactory substitute for linseed meal in the trio mixture. The pigs receiving linseed meal in the three Ohio tests reported gained a trifle faster and required a little less feed per unit of gain than those receiving cottonseed meal. A summary including these with five similar tests at other stations, however, showed an average difference of only 1.3 per cent in the rate of growth and of less than a half per cent in the feed required per unit of gain.

Approximately 2 pounds of oats for each pound of supplement were fed without slowing down the rate of growth. The oats decreased the effectiveness of the ration. This was apparently due

to the hulls, or to their more fibrous character, as, on a hull-free basis, there was very little difference in the feed required per unit of gain.

Linseed meal was omitted from the trio mixture when oats were fed without lowering the gains produced from a given amount of feed. The pigs fed linseed meal ate a little more feed daily and were ready for market 6 days earlier than those without it.

Hulled oats, fed with corn, the trio mixture, and minerals, at the rate of approximately 1.5 pounds for each pound of supplement, increased both the rapidity of the gains and the amount of gain from a given quantity of feed. The hulling charge and the loss in weight combined made hulled oats a relatively expensive feed. At the prices used, they were not profitable. Their feeding value, however, when they were fed in this way was 24.3 per cent greater a pound than that of corn. With the price of oats a pound not exceeding 87.5 per cent that of corn, the hulled oats would have been an economical feed.

Substituting approximately a pound of hulled oats for each half pound of linseed meal in the trio mixture resulted in faster gains and greater gains per unit of feed. The feeding value of commercial hulled oats used in this way was 60 per cent greater than that of an equal weight of corn. With this method of feeding, only a relatively small amount of oats can be utilized.

Feeding flour middlings with corn and tankage slightly increased the rate of growth, but not the efficiency of the ration. In eleven trials comparing corn and tankage with and without middlings, the middlings had an average feeding value 92.6 per cent that of an equal weight of corn. The middlings averaged 18.9 per cent of the total ration.

Standard middlings had a lower feeding value than flour middlings.

When both constituted 18 per cent of the ration, Palmo Midds showed a higher feeding value than standard middlings similar to those used in their manufacture. At a 25 per cent level Palmo Midds caused the ration to be distasteful at first and made a less favorable showing.

Cocoanut oil meal was worth 13.2 per cent more a pound than corn in the single test in which it was tried.

Cocoa bean oil meal proved toxic and unsuitable for pigs.

Dry-rendered tankage was more palatable and had a higher feeding value, on an equivalent protein basis, than steam-rendered tankage.

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